PREPARATION FOR THE OPERATIONS FR-2--E O L E

NOTE no.3.

OBJECT: DESCRIPTION OF THE OPERATION MODES OF THE SATELLITE FOR THE CALL OF THE BALLOONS. TELECOMMAND -- TELEPOSTING

Centre National d'Etudes Spatiales
Centre Spatial de Bretigny
Division Reseau
Centre d'Operations

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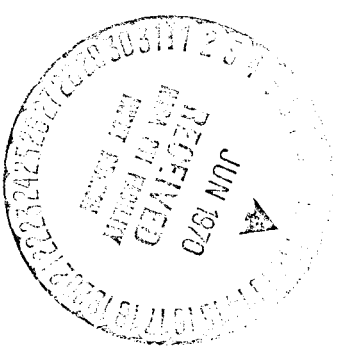

Space Center of Bretigny

"Network" Division

Operations Center

Preparation for the Operations

FR-2 EOLE

Note no. 3

Object: - Description of the operation modes of the satellite for the call of the balloons.
Telecommand - teleposting

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S U M M A R Y

I - INTRODUCTION

The call of the balloons is carried out by the satellite according to two different types:

- Sequential call (operation or destruction)
- Non sequential call (operation or destruction)

The synchronization call, joined to the non sequential call is produced automatically by the satellite.

In order to carry out these two call types, two modes of operation of the satellite are provided:

- Non programmed mode (TC telecommand)
- Programmed mode (TAF teleposting)

In the non programmed mode, the satellite equipment is set in operation by telecommand.

In programmed mode (TAF), the satellite equipment is set into operation by a program of orders, stored on board in a memorandum. The program is transmitted to the satellite by the telecommand connection.

II - PRINCIPAL CHARACTERISTICS OF THE TELECOMMAND/TELEPOSTING CONNECTION

Frequency	148.250 MHz
Type	TCN
Sub-bearing	9 745 Hz
Receiver sensitivity	- 103 dBm
On board antenna polarization	Right circular
Telecommand address	11111100 11111100
Teleposting address	00000011 00000011

III - DESCRIPTION OF THE TYPE OF CALL OF THE BALLOONS, BY THE SATELLITE

III-1 Sequential call

III-1-1 Non programmed mode (cf figure page 4)

Following an order transmitted by telecommand, the satellite successively transmits the call messages of the balloons: either in "operations call" (sequential operation or SM), or in "destruction call" (sequential destruction or SD).

The call order is unchangeable; it is defined by the binary sequence produced by the sequence register.

The first balloon called is any given one.

The satellite stops calling the balloons:

- on telecommand in the "operation call" case
- when balloon no. 511 has been called in the "destruction call" case.

III-1-2 Programmed mode (cf. figure pages 6 and 7)

It is after a "sequencial call" order transmitted by teleposting that the satellite successively transmits the call message of the balloons either in "operations call", or in "destruction call."

This teleposting order contains:

- the time of beginning of call,
- the first 9 bits (initial state of the register) of the 18 PN bits corresponding to the first balloon bn called in the sequence;
- the type of "operation sequential" call (SM) or "destruction sequential" call (SD)

If bn is the first balloon of the normal call sequence, the 511 balloons are interrogated (total sequential).

Appel séquentiel marche mode non programmé

Sequential call in non programmed operations mode

Call geginning by TC

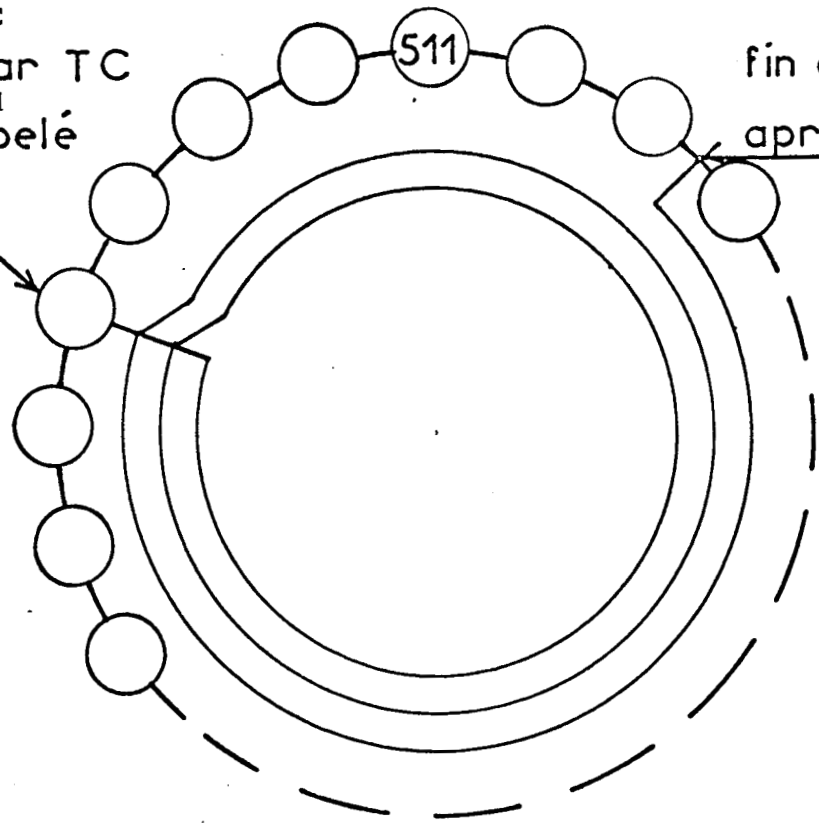
début appel par TC

First balloon called

1er ballon appelé

whatever it may be

quelconque



fin appel par TC

après n séquences

End of call by TC
after n sequences

Sequential call in non programmed destruction mode

Appel sequentiel destruction mode non programmé

début appel par TC

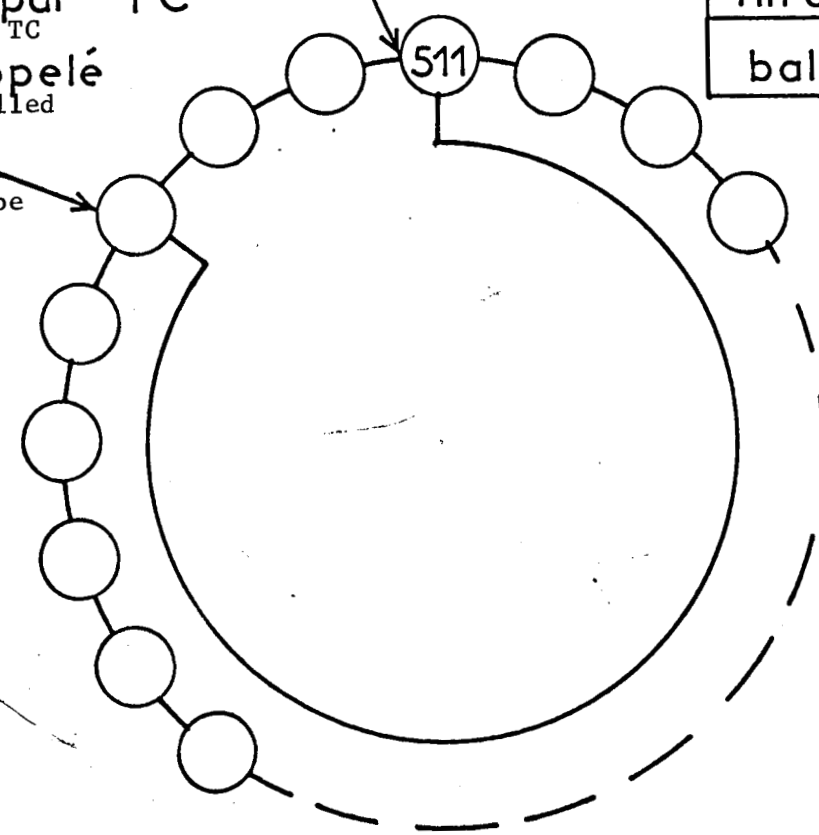
Call beginning by TC

1er ballon appelé

First balloon called

quelconque

whatever it may be



fin après 1er appel

ballon 511

End after first
call balloon 511

If bn is not the first balloon in the sequence, the balloon between bn and b 511 are the only ones to be interrogated (partial sequential).

As for the non programmed mode, the call order is unchangeable.

The satellite stops calling the balloons:

- in the "operation call" case at the time given in a teleposting order fixing the end of the call or the beginning of a new call.

- in the "destruction call" case when balloon no. 511 has been called.

III-2 Non sequential call (cf figure page 9)

The non sequential "operation" or "destruction" call is possible only in the programmed mode, thus on teleposting order.

The teleposting order contains:

- the time t of the beginning of call,

- the first 9 bits (initial state of the register) of the 18 PN bits corresponding to the balloon to be called.

- the "non sequential operation" type of call (NSM) or "destruction" (NSD).

At the time t, the satellite interrogates the chosen balloon every 40 s for 320 s, or 8 calls. This repetition is assured automatically by the satellite.

Since the interrogation of a balloon lasts 0.625 s, it is possible, in 40 s, to interrogate 64 balloons in the course of a "non sequential call" sequence.

In this case, the call order of the balloon is fixed by the order in which they appear in teleposting.

The satellite stops functioning automatically at t + 320 s if no teleposting or telecommand order release a new call.

Operations sequential call in non programmed mode (total sequence)

Appel sequentiel marche mode programmé (séquence totale)

Call beginning by TAF

début appel par TAF

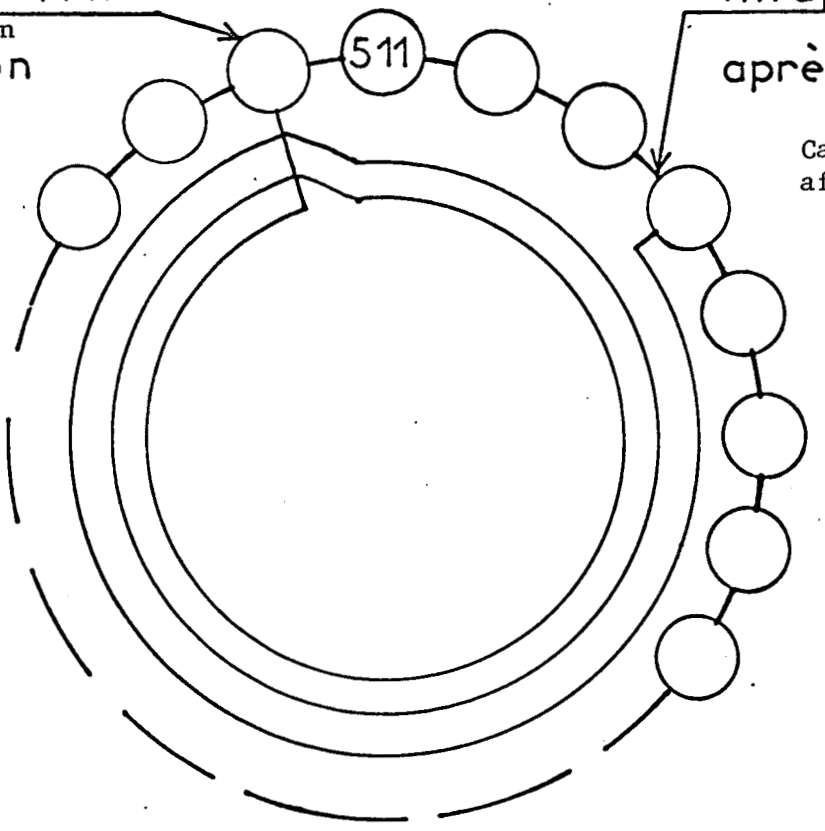
b_n is the first balloon in the sequence

b_n est le 1er ballon de la sequence

fin appel par TAF

après n séquences

Call ending by TAF after n sequences

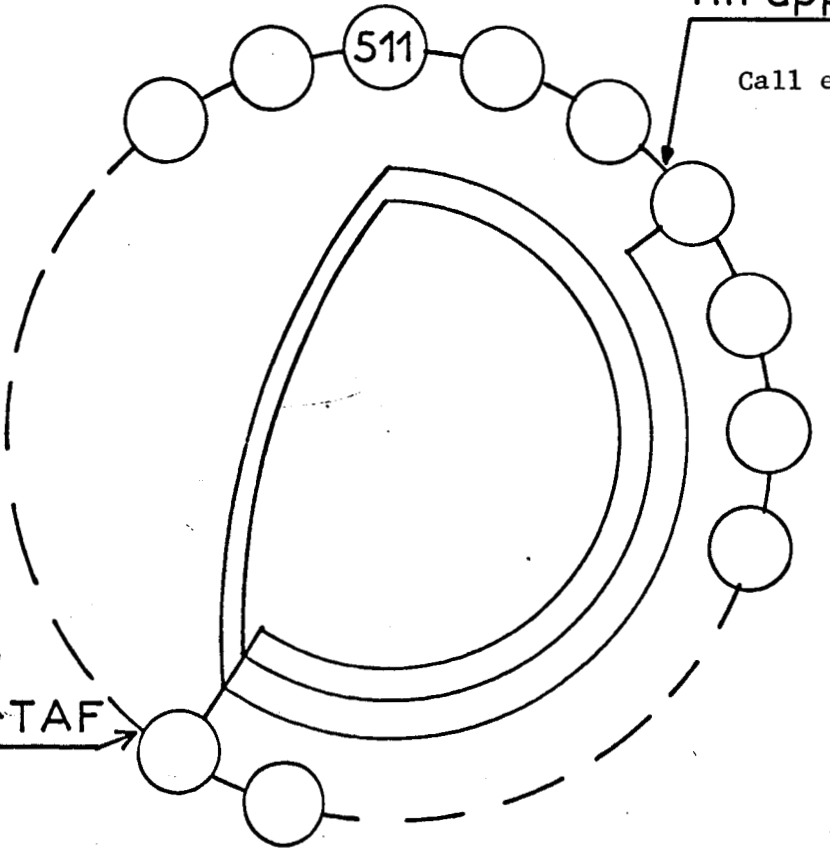


Appel séquentiel marche mode programmé (séquence partielle)

Operation sequential call in programmed mode (partial sequence)

fin appel par TAF

Call ending by TAF



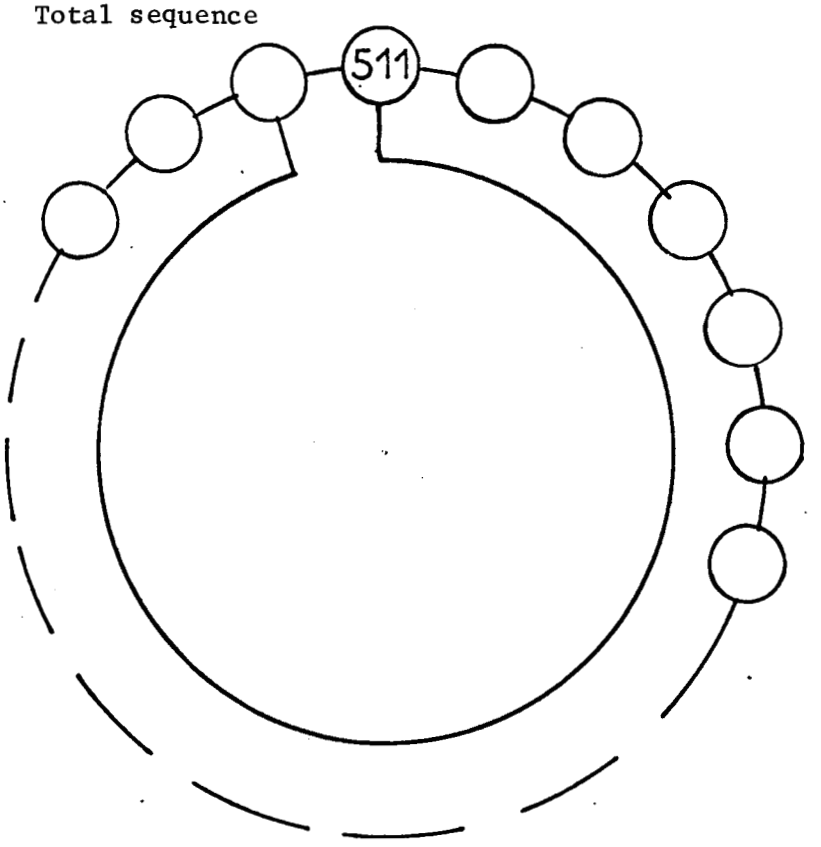
Call beginning by TAF

début appel parTAF

Appel séquentiel destruction mode programmé

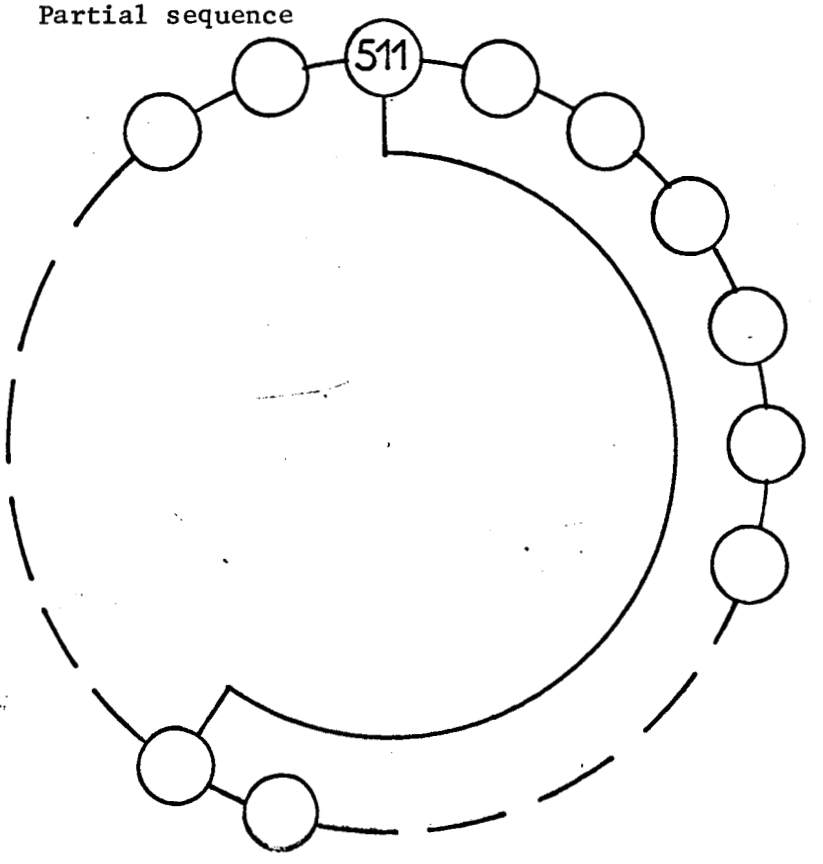
séquence totale

Total sequence



séquence partielle

Partial sequence



NOTE: If the number of balloons called is less than 64, the period of 40 s is not entirely utilized; the synchronization call takes place during dead times.

III-3 Resume of the miscellaneous balloon call modes

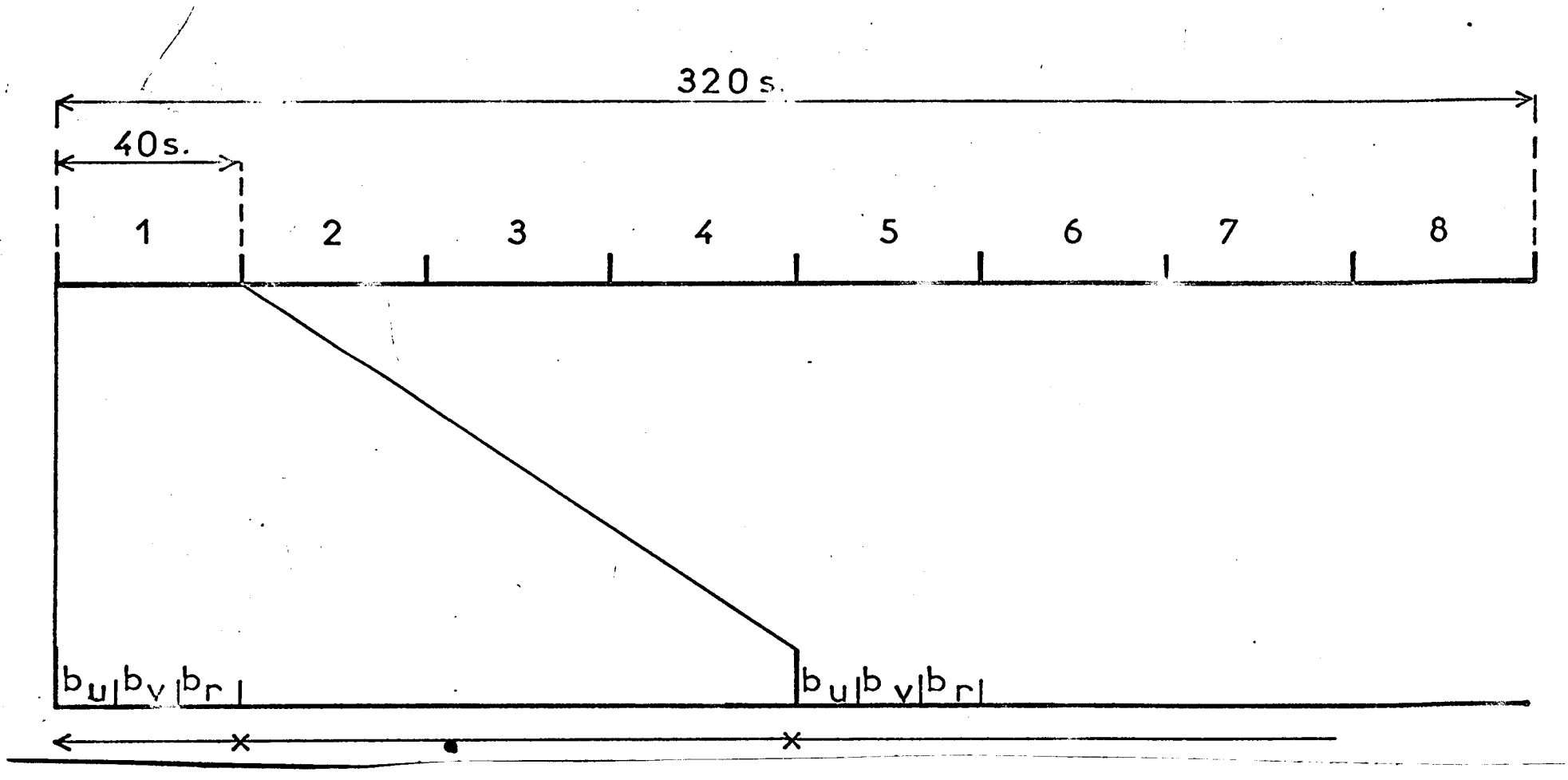
a) Non programmed mode

Type of call	Beginning of call	First balloon called	End of call
SM	on TC	whatever	on TC
SD	on TC	whatever	after call of balloon 511

b) Programmed mode

Type of call	Beginning of call	First balloon called	End of call
SM	Fixed moment in teleposting instruction	Balloon named in teleposting instruction	Moment fixed in following instruction
SD			After call of balloon 511
NSM	Fixed moment in one or several instructions if one or several balloons programmed.	Balloon named in the first instruction	After 320 s
NSD			

Non sequential operation or destruction call



Balloon call

Synchronization call

Repetition

IV - DESCRIPTION OF TYPES OF SATELLITE OPERATION

IV-1 Non programmed functions (TC)

The type of call chosen is executed or stopped by the time of reception of the corresponding telecommand order:

Order no.	Code 2^0 2^7	Posting	Function
17	11100010	14-02	Stopage of the UHF equipment
18	01110001	07-01	Programmed operation mode
19	10111000	11-08	Operation sequential call
20	01011100	05-12	Destruction sequential call

One telecommand sequence is composed of five words:

- words 1 and 2: address
- words 3, 4 and 5: execution

The bit of small weight is transmitted at the head.

IV-2 Program operation (teleposting)

In programmed operation, the satellite executes the call types which are given to it in the teleposting program instructions.

IV-2-1 Instructions

An instruction contains 24 bits divided into 3 words:

- 9 bits time
- 9 bits to designate the balloon to be interrogated
- 6 bits to designate the type of call

IV-2-1-1 Time

The hour fixes in satellite time the moment of execution. The bit of smallest weight changes every 320 s. The bit of heaviest weight changes

every 81 920 s. Thus the moments are fixed at near to 320 s and are included between:

0 s: 000000000 and

163 520 s 111111111

IV-2-1-2 Name of the balloon

The 9 bits do not give the exact name of the balloon but make up the first 9 bits of the corresponding "18 PN bits" word. They represent the initial state of the divergence register.

IV-2-1-3 Type of call

The type of call to be executed is given by a word of 6 bits according to the following code:

Operation sequential	SM	110110
Destruction sequential	SD	111010
Finish sequential	SF	001110
Non sequential operation	NSM	000101
Non sequential destruction	NSD	011101

IV-2-2 Memorandum

The instructions sent from the ground by the telecommand equipment is stored in a torus static memorandum whose capacity is limited to 64 instructions.

The teleposting memorandum is reset to zero:

- when it passes in item to store a new program

- when the number of instructions received is different from the number of instructions transmitted,

- when the "call type" order is mistaken at the time of reading and instruction.

IV-2-3 Use of the instructions

A programmer assures the use of the instructions placed in the memorandum.

The execution of the order takes place when there is a coincidence between the satellite time and the time given in the instructions.

The coincidence causes the placement on power of the equipment on board and the beginning of the call.

The stopage of equipment is automatically caused at the end of a call when it is no longer possible to obtain any coincidence of time with the following instructions.

When the programmer has given the order of execution of a call type contained in an instruction, there can only be a change of call type at the end of a call message (18 "PN" bits, 6 0 bits, 6 1 bits) for each message begun is obligatorily terminated.

Consequently, when two successive instructions carry the same execution time, the programmer carries out the first instruction and the corresponding call sequence begins. As there is still a time coincidence with the following instruction, the programmer carries out the second instruction which is executed at the end of the first call message of the preceding instruction. This configuration thus can be considered as prohibited.

This particularity is not valid for two or several successive instructions containing the non sequential call order, the balloons thus programmed are interrogated successively 8 times, or every 40 seconds.

The following table gives the operation of the satellite as a function of several pairs of instructions. Each instruction is represented by the following code:

t + n 320: time in seconds with n = or ≠ 0

bi, bj...: name of the balloon

S - NS - SF: type of call

Pair of successive instructions	Value of n	Moment of execution	Actions
t bi S t + n 320 bj S	0		Prohibited configuration
	⩾1	t t + n 320	Execution of first sequential call Stop of first call Execution of the second sequential call
t bi S t + n 320 bj NS	0		Prohibited configuration
	⩾1	t t + n 320 t + (n+1) 320	Execution sequential call Stop sequential call Execution non sequential call Stopage of the UHF equipment
t bi S t + n 320 b bj SF	0		Prohibited configuration
	⩾1	t t + n 320	Execution sequential call (Stop sequential call)Stop UHF equipment
t bi NS t + n 320 bj NS	0	t	Non sequential call of balloons bi, bj
	1	t t + 320 t + 640	Non sequential call of balloon bi Non sequential call of balloon bj Stop call - stop UHF
	⩾2	t t + 320 t + n 320 t + (n+1) 320	Non sequential call of balloon bi Equipment stop Non sequential call of balloon bj Stop call - UHF equipment stop
t bi NS t + n 320 bj S	0		Prohibited configuration
	1	t t + 320	Non sequential call balloon bi Execution sequential call
	⩾2	t t + 320 t + n 320	Non sequential call balloon bi UHF equipment stop Execution sequential call

V - TELEPOSTING MESSAGE

V-1 Composition

A teleposting message is composed of three parts:

- an initial sentence,
- the instruction sentences,
- a final sentence.

V-1-1 Initial sentence

This is a sentence of 24 bits distributed in 4 words of 6 bits (I_1 to I_4).

It serves as a beginning for the message and positions the TAF memorandum writing operation.

Its composition which is constant is the following:

I_1	I_2	I_3	I_4
2^0 2^5	2^0 2^5	2^0 2^5	2^0 2^5
0 0 0 0 0 1	0 0 0 0 0 1	0 0 0 0 0 1	0 0 0 0 0 1

V-1-2 Instructions sentences (cf § IV-2)

2^0 HEURE Time 2^8	2^0 N° BALLON Balloon no. 2^8	2^0 ORDRE Order 2^5
0 0 0 0 0 0 0 0 1	0 1 0 1 1 0 0 0 0	1 1 0 1 1 0

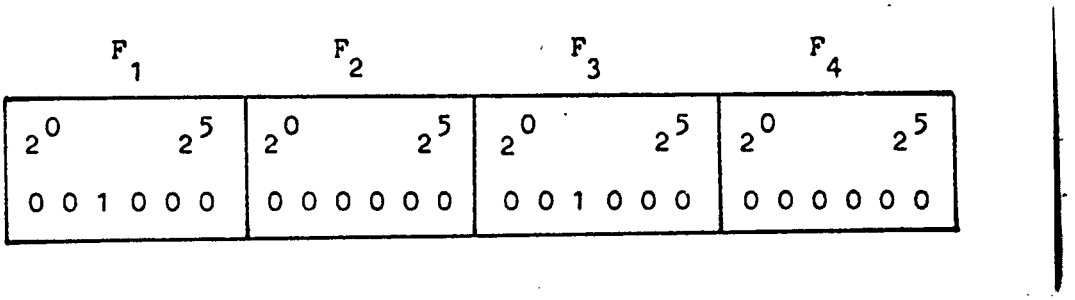
V-1-3 Final sentence

This is a sentence of 24 bits distributed in 4 words of 6 bits. It serves to end a message and positions the TAF memorandum in reading operation.

Its composition is the following:

Words F_2 and F_4 constant: 0 0 0 0 0 0

The words F1 and F_3 both give the number of instruction sentences contained in the program.



V-2 Realization

V-2-1 Transmission of the teleposting message

- The transmission of the message is carried out for each word of each sentence, small weight bit at the head.

- In order to be accepted by the satellite, each sentence must be preceded by the teleposting address:

0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1

- The sentences are successively transmitted without intervals.

- After the final sentence, the message is obligatorily ended by Synchronization - Interval.

- The utilization of the telecommand equipment as a T.C.N. function imposes three constraints:

. the words are of 8 bits,

. the number 1 and number 0 is in the relationship 4/4

. the automatic mode is the only one possible.

In order to satisfy these requirements, it is necessary to precede to a transformation of the binary information in a code compatible with the GS1 coder, and to present the messages thus coded on a telegraphic support band of 5 moments.

V-2-2 Coding of the binary information

Six information bits are converted to 8 coder bits, thus the 24 bits of each sentence are assembled in 4 words of 6 bits and converted to 4 words of 8 bits.

The initial and final sentences which normally contain 4 words of 6 bits are easily converted to 4 words of 8 bits.

On the other hand, for the instruction sentences which are composed of 2 words of 9 bits and 1 word of 6 bits, it is necessary to distribute these bits in the following way:

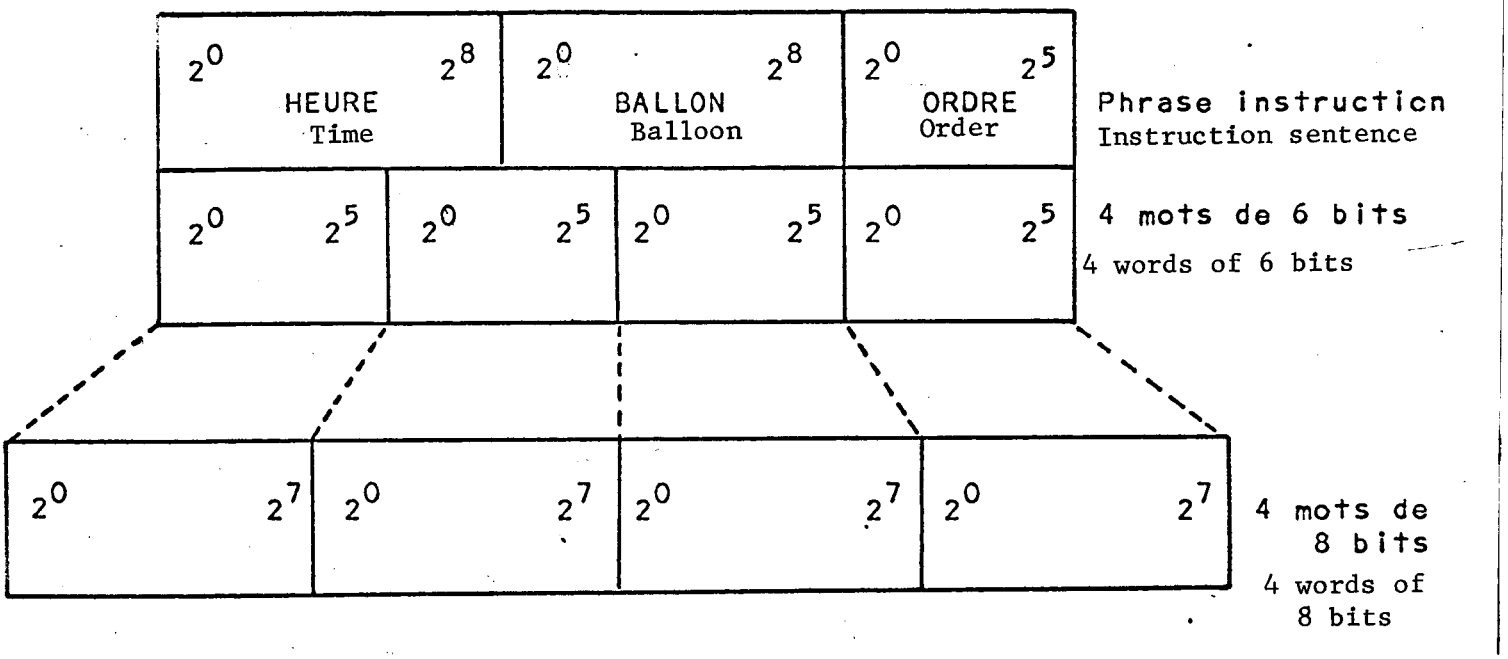
1st word: time bit of weight 2^0 to 2^5

2nd word: time bit of weight 2^6 to 2^8

name of the balloon bit weight 2^0 to 2^2

3rd word: name of the balloon bit of weight 2^3 to $2^{(\text{not legible})}$

4th word: order bit of weight 2^0 to 2^5



Conversion of the words of 6 bits to words of 8 bits

The conversion follows the following rules:

- The bits of weight 2^1, 2^2, 2^4 of the word of 6 bits give a base combination number (or 8 combinations).

- The bits of weight 2^0, 2^3, 2^5 of the word of 6 bits give the divergence number which should be applied to the base combination in order to find the final word of 8 bits (or 8 divergences).

NOTE - The number of the base combination is found again in the word of eight initial bits by combining the weights 2^2, 2^3 and 2^5.

The base combinations are:

	2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7
C0	1	1	0	0	1	0	1	0
C1	1	1	0	0	0	1	1	0
C2	1	1	0	1	0	0	1	0
C3	1	1	0	1	0	1	0	0
C4	1	1	1	0	0	1	0	0
C5	1	1	1	0	0	1	0	0
C6	1	1	1	1	0	0	0	0
C7	0	1	1	1	0	1	0	0

Example:

Thus to be transmitted:

2^0	2^1	2^2	2^3	2^4	2^5
0	1	1	1	0	1

Combination number 110 or C6: 1 1 1 1 0 0 0 0

Divergence 011 or 3 : 0 0 0 1 1 1 1 0

The table of annex 1 gives for the 64 decimal values:

- the binary equivalent (word of 6 bits)
- the coder equivalent (word of 8 bits)
- the equivalent in sexadecimal code
- the equivalent in telegraphic code

V-2-3 Presentation on telegraphic bands

- The information is introduced in the coder with the help of a 5 track perforated band;

- The 5th track determines the function (perforation - TCN)

- The first four tracks represent 4 bits of each word, the coder successively reads 2 characters in succession on the band in order to transmit 1 word of 8 bits.

(Perforation = value 1)

Each word of 8 bits is divided into 2 parts to which one gives the following weight:

2^0 2^1 2^2 2^3 2^4 2^5 2^6 2^7

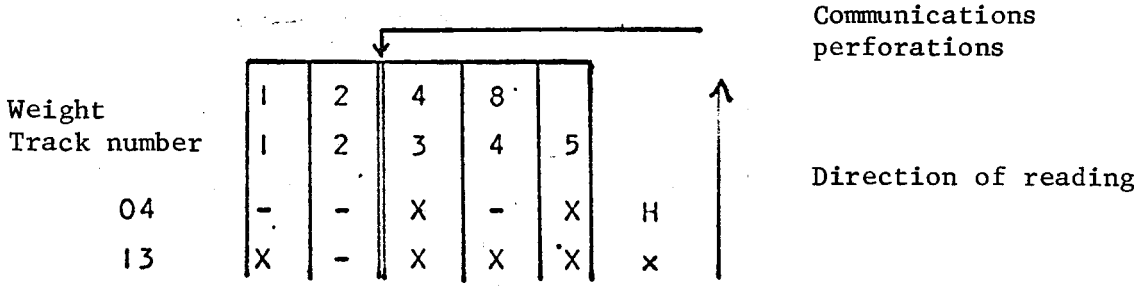
8 4 2 1 8 4 2 1

It is thus possible to assign a sexadecimal code for each word of 8 bits:

0 1 0 0 1 1 0 1

04 - 13

The sexadecimal-telegraphic character code correspondence is the following:



The end of the message is obligatorily terminated on the perforated band by the telegraphic characters KK which correspond to the end of transmission (Interval - Synchronization stop coder).

Example

Thus the following instructions to be transmitted:

at 320 s see operations sequential call beginning with balloon 364

The corresponding teleposting message contains:

- Initial sentence (words of 6 bits)

0 0 0 0 0 1	0 0 0 0 0 1	0 0 0 0 0 1	0 0 0 0 0 1

Initial sentence (words of 8 bits)

0 1 1 0 0 1 0 1	0 1 1 0 0 1 0 1	0 1 1 0 0 1 0 1	0 1 1 0 0 1 0 1

Initial sentence in sexadecimal code (with the address):

00-03, 00-03, 06-05, 06-05, 06-05, 06-05

Initial phrase in teletype code (with the address);

T-W, T-W, P-Y, P-Y, P-Y, P-Y

- Instructions sentences (24 bits)

1 0 0 0 0 0 0 0 0 0	1 1 1 0 1 0 0 0 0	1 1 0 1 1 0

Instruction sentence (words of 6 bits)

1 0 0 0 0 0	0 0 0 1 1 1	0 1 0 0 0 0	1 1 0 1 1 0

Instruction sentence (words of 8 bits)

1 0 1 0 1 1 0 0	1 1 0 1 1 0 0 0	1 1 1 0 0 0 1 0	1 0 0 1 0 0 1 1

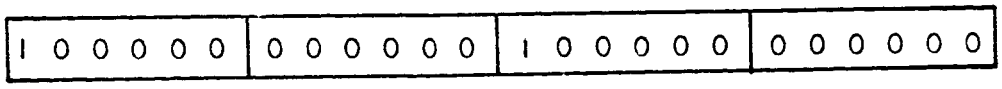
Instruction sentence sexadecimal code (with the address);

15-12, 00-03, 10-12, 13-08, 14-02, 08-03

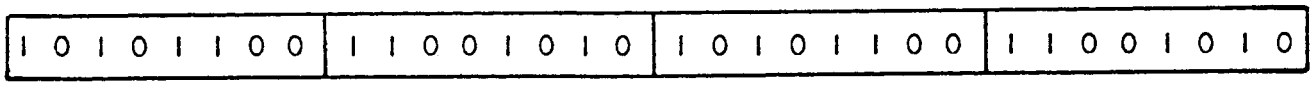
Instruction sentence telegraphic code (with address):

Letter-M, T-W, G-M, X-O, V-L, B-W

Final sentence (words of 6 bits)



Final sentence words of 8 bits



Final sentence sexadecimal code (with address):

00-03, 00-03, 10-12, 12-10, 10-12, 12-10

Final sentence teletype code (with the address):

Letter-M, T-W, G-M, M-G, G-M, M-G

Corresponding telegraphic bands

Letter - M - T - W - P - Y - P - Y - P - Y - P - Y

Letter - M - T - W - G - M - X - O - V - L - B - W

Letter - M - T - W - G - M - M - G - G - M - M - G

K - K

Decimal mark	Words of 6 bits 2^0 2^5	Equivalent words of 8 bits 2^0 2^7	Sexadecimal code	Telegraphic code
0	0 0 0 0 0 0	1 1 0 0 1 0 1 0	12 - 10	M - G
1	1 0 0 0 0 0	1 0 1 0 1 1 0 0	10 - 12	G - M
2	0 1 0 0 0 0	1 1 1 0 0 0 1 0	14 - 02	V - L
3	1 1 0 0 0 0	0 0 1 0 1 1 1 0	02 - 14	L - V
4	0 0 1 0 0 0	1 1 0 1 0 0 1 0	13 - 02	X - L
5	1 0 1 0 0 0	0 0 1 0 1 1 0 1	02 - 13	L - X
6	0 1 1 0 0 0	1 1 1 1 0 0 0 0	15 - 00	Letter T
7	1 1 1 0 0 0	0 0 0 0 1 1 1 1	00 - 15	T letter
8	0 0 0 1 0 0	1 0 1 1 0 0 1 0	11 - 02	Sipher L
9	1 0 0 1 0 0	0 0 1 0 1 0 1 1	02 - 11	L sipher
10	0 1 0 1 0 0	1 0 1 1 1 0 0 0	11 - 08	Sipher 0
11	1 1 0 1 0 0	1 0 0 0 1 0 1 1	08 - 11	0 sipher
12	0 0 1 1 0 0	1 0 1 1 0 1 0 0	11 - 04	Sipher H
13	1 0 1 1 0 0	0 1 0 0 1 0 1 1	04 - 11	H sipher
14	0 1 1 1 0 0	0 0 1 1 1 1 0 0	03 - 12	W - M
15	1 1 1 1 0 0	1 1 0 0 0 0 1 1	12 - 03	M - W
16	0 0 0 0 1 0	1 1 0 0 0 1 1 0	12 - 06	M - P
17	1 0 0 0 1 0	0 1 1 0 1 1 0 0	06 - 12	P - M
18	0 1 0 0 1 0	1 1 1 0 0 1 0 0	14 - 04	V - H
19	1 1 0 0 1 0	0 1 0 0 1 1 1 0	04 - 14	H - V
20	0 0 1 0 1 0	1 1 0 1 0 1 0 0	13 - 04	X - H
21	1 0 1 0 1 0	0 1 0 0 1 1 0 1	04 - 13	H - X
22	0 1 1 0 1 0	0 1 1 1 0 1 0 0	07 - 04	Q - H
23	1 1 1 0 1 0	0 1 0 0 0 1 1 1	04 - 07	H - Q
24	0 0 0 1 1 0	1 0 1 1 0 0 0 1	11 - 01	Sipher Z
25	1 0 0 1 1 0	0 0 0 1 1 0 1 1	01 - 11	Z sipher
26	0 1 0 1 1 0	0 0 1 1 1 0 0 1	03 - 09	W - B
27	1 1 0 1 1 0	1 0 0 1 0 0 1 1	09 - 03	B - W
28	0 0 1 1 1 0	0 0 1 1 0 1 0 1	03 - 05	W - Y
29	1 0 1 1 1 0	0 1 0 1 0 0 1 1	05 - 03	Y - W
30	0 1 1 1 1 0	0 0 0 1 1 1 0 1	01 - 13	Z - X
31	1 1 1 1 1 0	1 1 0 1 0 0 0 1	13 - 01	X - Z
32	0 0 0 0 0 1	0 1 1 0 0 1 0 1	06 - 05	P - Y
33	1 0 0 0 0 1	0 1 0 1 0 1 1 0	05 - 06	Y - P

Decimal mark	Words of 6 bits 2^0 2^5	Equivalent words of 8 bits 2^0 2^7	Sexadecimal code	Telegraphic code
34	0 1 0 0 0 1	0 1 1 1 0 0 0 1	07 - 01	Q - Z
35	1 1 0 0 0 1	0 0 0 1 0 1 1 1	01 - 07	Z - Q
36	0 0 1 0 0 1	0 1 1 0 1 0 0 1	06 - 09	P - B
37	1 0 1 0 0 1	1 0 0 1 0 1 1 0	09 - 06	B - P
38	0 1 1 0 0 1	0 1 1 1 1 0 0 0	07 - 08	Q - O
39	1 1 1 0 0 1	1 0 0 0 0 1 1 1	08 - 07	O - Q
40	0 0 0 1 0 1	0 1 0 1 1 0 0 1	05 - 09	Y - B
41	1 0 0 1 0 1	1 0 0 1 0 1 0 1	09 - 05	B - Y
42	0 1 0 1 0 1	0 1 0 1 1 1 0 0	05 - 12	Y - M
43	1 1 0 1 0 1	1 1 0 0 0 1 0 1	12 - 05	M - Y
44	0 0 1 1 0 1	0 1 0 1 1 0 1 0	05 - 10	Y - G
45	1 0 1 1 0 1	1 0 1 0 0 1 0 1	10 - 05	G - Y
46	0 1 1 1 0 1	0 0 0 1 1 1 1 0	01 - 14	V - Z
47	1 1 1 1 0 1	1 1 1 0 0 0 0 1	14 - 01	Z - V
48	0 0 0 0 1 1	0 1 1 0 0 0 1 1	06 - 03	P - W
49	1 0 0 0 1 1	0 0 1 1 0 1 1 0	03 - 06	W - P
50	0 1 0 0 1 1	0 1 1 1 0 0 1 0	07 - 02	Q - L
51	1 1 0 0 1 1	0 0 1 0 0 1 1 1	02 - 07	L - Q
52	0 0 1 0 1 1	0 1 1 0 1 0 1 0	06 - 10	P - G
53	1 0 1 0 1 1	1 0 1 0 0 1 1 0	10 - 06	G - P
54	0 1 1 0 1 1	0 0 1 1 1 0 1 0	03 - 10	W - G
55	1 1 1 0 1 1	1 0 1 0 0 0 1 1	10 - 03	G - W
56	0 0 0 1 1 1	1 1 0 1 1 0 0 0	13 - 08	X - O
57	1 0 0 1 1 1	1 0 0 0 1 1 0 1	08 - 13	O - X
58	0 1 0 1 1 1	1 0 0 1 1 1 0 0	09 - 12	B - M
59	1 1 0 1 1 1	1 1 0 0 1 0 0 1	12 - 09	M - B
60	0 0 1 1 1 1	1 0 0 1 1 0 1 0	09 - 10	B - G
61	1 0 1 1 1 1	1 0 1 0 1 0 0 1	10 - 09	G - B
62	0 1 1 1 1 1	1 0 0 0 1 1 1 0	08 - 14	O - V
63	1 1 1 1 1 1	1 1 1 0 1 0 0 0	14 - 08	V - O